JENSEN HUGHES

Advancing the Science of Safety

Improving the Modeling of Electrical Cabinet Fires through RACHELLE-Fire

Session TH-32
RES Improving Realism in Fire Probabilistic Risk Assessments

Joelle DeJoseph, PE
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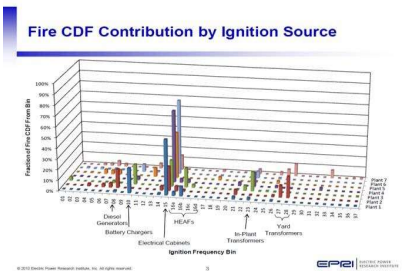
Improving the Modeling of Electrical Cabinet Fires

Why is there a need for improvement?



Improving the Modeling of Electrical Cabinet Fires

Removing known conservatisms through:

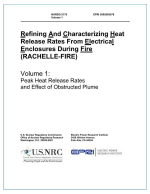
- Additional Experiments
  - NUREG/CR-7197; Heat Release Rates of Electrical Enclosure Fires (HELEN-Fire)
- Operating experience
  - Decades of fire event experience (EPRI's Update Fire Events Database – EPRI 1025284)
- Working group consisted of experienced fire protection and fire probabilistic risk assessment researchers and practitioners
  - Insights from practitioners to evolve methodology

What's in RACHELLE-Fire?

Refining **A**nd **C**haracterizing **H**eat Release Rates From **El**ectrical **E**nclosures During **Fire**

Volume 1: Peak Heat Release Rates and Effect of Obstructed Plume

- Expanded classification of cabinets / enclosures
- Revised heat release rate distributions
- Fuel assessment impacting peak HRR
- Fire diameter sizing guidance
- Obstructed plume
- Pilot application



(NUREG-2178/EPRI 3002005578)

RACHELLE-Fire Working Group

Results and approaches presented in RACHELLE-Fire represent the working groups consensus opinion

Representation was balanced between the regulator and the nuclear power industry

- Four members from the U.S. Nuclear Regulatory Commission (NRC) /National Laboratories
- Four members from Electric Power Research Institute (EPRI) /nuclear power industry

Comments from the regulator, the nuclear power industry, and the public were addressed by the working group.

NUREG/CR-6850 / EPRI 1011989

HRR distributions from Table G-1

- Recommended HRR Values for Electrical Fires

Ignition Source	HRR kW (Btu/s)		Gamma Distribution	
	75th	98th	α	β
Vertical cabinets with qualified cable, fire limited to one cable bundle	69 [1] (65)	211 [2] (200)	0.84 (0.83)	59.3 (56.6)
Vertical cabinets with qualified cable, fire in more than one cable bundle	211 [2] (200)	702 [3] (665)	0.7 (0.7)	216 (204)
Vertical cabinets with unqualified cable, fire limited to one cable bundle	90 [4] (85)	211 [2] (200)	1.6 (1.6)	41.5 (39.5)
Vertical cabinets with unqualified cable, fire in more than one cable bundle closed doors	232 [5] (220)	464 [6] (440)	2.6 (2.6)	67.8 (64.3)
Vertical cabinets with unqualified cable, fire in more than one cable bundle open doors	232 [5] (220)	1002 [7] (950)	0.46 (0.45)	386 (366)

HRR for Functionally Based Groups

Table 4-1
Peak HRR Distributions for Functionally Based Classification Groups 1, 2, and 3 Enclosures

Classification Group	Fuel Type* (TS/QTP/SIS or TP)	Alpha	Beta	75th Percentile (kW)	98th Percentile (kW)
1 – Switchgear and Load Centers	TS/QTP/SIS	0.32	79	30	170
	TP	0.99	44	60	170
2 – MCCs and Battery Chargers	TS/QTP/SIS	0.36	57	25	130
	TP	1.21	30	50	130
3 – Power Inverters	TS/QTP/SIS	0.23	111	25	200
	TP	0.52	73	50	200

HRR for Volumetric Size Based Groups

Table 4-2
Peak Heat Release Rate Distributions for Classification Group 4 (All Other) Electrical Enclosures

Enclosure Class/Function Group	Enclosure Ventilation (Open or Closed Doors)	Fuel Type* (TS/QTP/SIS or TP Cables)	Gamma Distribution Characteristics											
			(a) Default				(b) Low Fuel Loading				(c) Very Low Fuel Loading			
			Alpha	Beta	75th Percentile (kW)	98th Percentile (kW)	Alpha	Beta	75th Percentile (kW)	98th Percentile (kW)	Alpha	Beta	75th Percentile (kW)	98th Percentile (kW)
4a – Large Enclosures >1.42 m³ (>50 ft³)	Closed	TS/QTP/SIS	0.23	223	50	400	0.23	111	25	200	0.38	32	15	75
	Closed	TP	0.52	145	100	400	0.52	73	50	200	0.88	21	25	75
	Open	TS/QTP/SIS	0.26	365	100	700	0.26	182	50	350	0.38	32	15	75
	Open	TP	0.38	428	200	1000	0.38	214	100	500	0.88	21	25	75
4b – Medium Enclosures ≤1.42 m³ (50 ft³) and > 0.34 m³ (12 ft³)	Closed	TS/QTP/SIS	0.23	111	25	200	0.27	51	15	100	0.88	12	15	45
	Closed	TP	0.52	73	50	200	0.52	36	25	100	0.88	12	15	45
	Open	TS/QTP/SIS	0.23	182	40	325	0.19	92	15	150	0.88	12	15	45
	Open	TP	0.51	119	80	325	0.30	72	25	150	0.88	12	15	45
4c – Small Enclosures ≤ 0.34 m³ (12 ft³)	Not Applicable	All	0.88	12	15	45	The fuel load characterization approach is not applicable to small enclosures.							

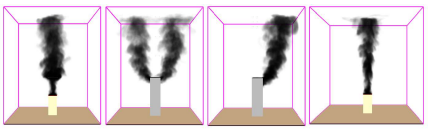
Improvement on Distributions

Comparison of HRR distributions

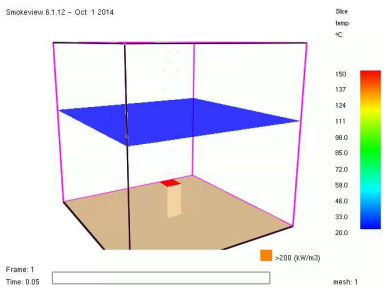
- TS/QTP/SIS: Thermoset / *Qualified* Thermoplastic (passed IEEE-383 vertical flame spread test) / SIS
  - NUREG/CR-6850 → 2 HRR distributions
  - RACHELLE-Fire → 16 HRR distributions
- TP: *Unqualified* Thermoplastic
  - NUREG/CR-6850 → 3 HRR distributions
  - RACHELLE-Fire → 16 HRR distributions

Obstructed Plume Simulations

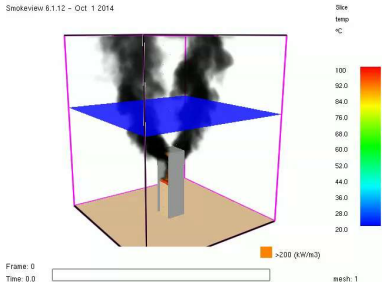
RACHELLE-Fire presents methodology to correct for the ZOI due to the obstructed plume effect encountered in electrical enclosures.



Unobstructed Plume



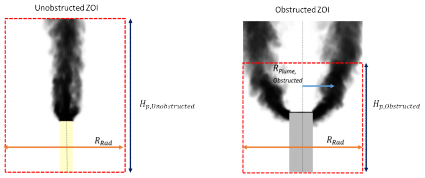
Obstructed Plume



Obstructed Plume Treatment in FPRA

Implementing the obstructed plume reduces the vertical ZOI

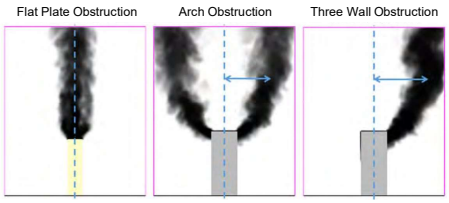
- Vertical → 24% reduction in vertical ZOI distance



Obstructed Plume Treatment in FPRA

Did not explore improvements to horizontal ZOI

- Horizontal → none
  - The thermal radiation ZOI extends farther than the plume will be shifted by the top obstruction



Implementing RACHELLE-Fire

This activity requires verification of cabinet configurations!

What to look out for:

- Can't just apply the new HRR distributions to existing scenarios without checking
  - Function of electrical cabinet
  - Physical size of electrical cabinet
  - Open vs closed configuration
  - *May* need to open and explore internals of electrical cabinet

What did we gain?

RACHELLE-Fire was able to reduce the conservatisms found in electrical cabinet fire scenarios

- Guidance is user friendly
- Guidance is more applicable to the variety of cabinets
- Guidance is repeatable
- Guidance is more representative of industry fire OE (more small fires)

QUESTIONS?

Contact
Joelle DeJoseph
+1 919-215-8735
jdejoseph@jensenhughes.com

For More Information Visit
www.jensenhughes.com

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